RESEARCH HIGHLIGHTS

Technical Series 00-123

OPTIMIZATION OF IMPACT SOUND INSULATION IN STEEL-FRAME FLOORS IN RESIDENTIAL BUILDINGS

Introduction

This research deals with the improvement of impact sound insulation for steel-frame floors in residential buildings. In fact, impact sound represents the major acoustic privacy problem in this type of multi-unit residential structure, particularly when the floors have hard finishes, such as hardwood, ceramic and even linoleum.

Essentially this study had two objectives: to develop and test the effectiveness of various types of floating floors and subsequently, to increase ceiling insulation for vibratory noises (impact sound) transmitted through the steel-frame. It should be noted here that reducing the transmission of impact sound also reduces air-borne noise.

For floating floors, various materials, floor thicknesses, and floor assembly variables such as mass, rigidity, and use of sleepers were tested in sixteen (16) different floor samples.

For ceilings, the mechanical connections of the furring and the separation of the ceiling from the gypsum wallboard were evaluated for five (5) different ceiling assemblies.

Finally, different floor finishes were added to various floating floors combined with two different ceiling assemblies, a conventional ceiling and an independent ceiling, to verify their total impact sound insulation.

This study was conducted using a test bench designed to approximate as closely as possible real construction conditions. This test bench is similar to a 60 m^3 reverberant room which made it possible to conduct all the laboratory tests and at the same time to obtain levels approximating those which can be measured on site.

More information on floating floors, used to reduce impact sound transmission through steel-frame floors, can be gleaned from this study. The measurement results are given in Table 1. Firstly, an increase in the mass per unit area of the floating floors generates a certain increase in the IIC. In addition, when sleepers are added to the same assembly and when using the same resilient material, the impact insulation class (IIC) is enhanced by approximately 5 dB. Moreover, if mineral wool is inserted in the air spaces between the sleepers, (depending on the mass per unit area of the type of sandwich panel and on the resilient material used) it is also possible to increase the IIC obtained by approximately 4 to 6 dB.

Another important element in the design of a floating floor is the choice of the resilient material. As can be observed in the results shown in Table 1, granular rubber (Duralux) is more resilient than cork pads and rubber agglomerate (CDM type 12), and this resilience is clearly reflected in a higher IIC rating. Moreover, the optimal thickness depends on the material chosen. In the case of granular rubber, the thicker the layer, the higher the impact sound insulation value, whereas for the anti-vibration pads, a 10 mm to 20 mm increase in thickness does not significantly change the IIC rating.

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Table 1: IIC values and average losses at dominating frequencies (between 125 Hz and 250 Hz) for floating concrete slab for the different floor samples				
Sample No.	**Description of floating floor sample**	**Floating Floor thickness (mm) (mass per unit area of sandwich panel) (Kg/m^2) ***	**IIC Rating dB units**	**Average losses at dominating frequencies of concrete floating slab (125-250 Hz) (dB acc.)**
0	concrete slab alone		39	
1	19 mm plywood 10 mm Duralux (rubber)	29 (11.4)	40	28.3
2	16 mm glued plywood 16 mm firecode gypsum board 10 mm Duralux (rubber)	42 (18.9)	40	24.5
3	16 mm glued plywood 16 mm firecode gypsum board 16 mm firecode gypsum board 10 mm Duralux (rubber)	58 (30.0)	43	27.2
4	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 10 mm Duralux (rubber)	38 (16.9)	41	26.2
5	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 18 mm Duralux (rubber)	44 (16.9)	44	29.7
6	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 10 mm Duralux (rubber) 10 mm Duralux (rubber)	48 (16.9)	46	30.6
7	19 mm plywood 19 mm glued sleepers 10 mm Duralux strips	48 (11.4)	45	39.0
8	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 19 mm glued sleepers 10 mm Duralux strips	57 (16.9)	47	34.6
9	19 mm plywood 19 mm glued sleepers 10 mm CDM** insulating blocks	48 (11.4)	40	36.3
10	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 19 mm glued sleepers 10 mm CDM insulating blocks	57 (16.9)	44	37.2
11	19 mm plywood 19 mm glued sleepers 25 mm mineral wool 10 mm CDM insulating blocks	48 (11.4)	46	38.3

Table 1: (Continued)

12	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 19 mm glued sleepers 25 mm mineral wool 10 mm CDM insulating blocks	57 (16.9)	48	37.1
13	19 mm plywood 19 mm glued sleepers 25 mm mineral wool 20 mm CDM insulating blocks	58 (11.4)	46	37.9
14	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 19 mm glued sleepers 25 mm mineral wool 20 mm CDM insulating blocks	67 (16.9)	47	37.3
15	19 mm plywood 19 mm glued sleepers 25 mm mineral wool 18 mm Duralux strips	54 (11.4)	47	39.2
16	9 mm glued plywood 9 mm firecode gypsum board 9 mm glued plywood 19 mm glued sleepers 25 mm mineral wool 18 mm Duralux strips	63 (16.9)	48	37.9

*NOTE: This mass per unit area value does not include the mass of the sleepers, the mineral wool nor the resilient materials (Duralux or CDM).
**NOTE: Cork and rubber agglomerate manufactured by CDM.

The second part of the study demonstrated the influence of ceilings in the insulation of steel-frame floors against impact sound. The results of these measurements are reproduced in Table 2. Among the five (5) types of ceilings tested, the poorest acoustic performance is given by the conventional ceiling which is most often found in this type of structure (ceiling type 1). The addition of mineral wool in the air space above the ceiling (ceiling type 2) increases the IIC rating slightly. Moreover, increasing the mass, i.e., adding a second gypsum board sheet (ceiling type 4) enhances the impact sound insulation considerably. On the other hand, when the two gypsum board sheets are separated by resilient channels, the results are the same or worse than for the model without the channels (ceiling type 3). Thus the addition of resilient channels between the gypsum board sheets is not recommended.

Table 2: IIC ratings for various ceiling types

	Floor Samples					
Ceiling Type	**Slab 1**	**2**	**3**	**8**	**12**	**15**
Without ceiling finish	39	40	43	47	48	47
No. 1: 16 mm gypsum sheet on furrings 400 mm o.c.	48	48	51	55	49	49
No. 2: 16 mm gypsum sheet on furrings 400 mm o.c., plus 150 mm mineral wool in air space	48	49	51	54	52	53
No. 3: Two 16 mm gypsum sheets on furrings 400 mm o.c., plus 150 mm mineral wool in air space	48	50	52	55	56	53
No. 4: one 16 mm gypsum sheet on furrings 400 mm o.c., second sheet attached to resilient channels 600 mm o.c., plus 150 mm mineral wool in air space	48	50	52	55	52	52
No. 5: one 16 mm gypsum sheet on furrings 400 mm o.c., with anti-vibratory insulation, plus 150 mm mineral wool in air space and peripheral separation	50	51	52	53	53	54

For the ceiling with resilient hangars independent of the peripheral walls (ceiling type 5), the results are clearly better than those obtained for the conventional ceiling (ceiling type 1). With the conventional ceiling, the vibrations in the concrete slab forming the ceiling of the room below are transmitted directly to the gypsum board, and even frequencies under 630 Hz can be amplified. On the other hand, the ceiling with a resilient hangar system dampens to a great extent the vibrations from the concrete slab. This vibratory dampening is also obtained for the party wall, due to the independence of the ceiling.

Finally, it is difficult to obtain an IIC-65 rating, regardless of the type of ceiling built, in the presence of hard floor finishes such as ceramic or hardwood. On the other hand, with a good quality carpet flooring and underlay, the IIC rating increases considerably. When this type of finish is used, the independent ceiling is better than the conventional ceiling. The results of these measurements are reproduced in Table 3. With a hardwood floor finish, the impact sound insulating capacity is slightly reduced for the independent ceiling. This point should be tested, however, on a test structure with larger dimensions.

Table 3: IIC ratings for ceiling types 1 and 5 for the various types of floating floors and finishes

Sample no.	Type of floating floors with finish	IIC Rating Ceiling 1	IIC Rating Ceiling 5
17	Glued ceramic 16 mm plywood 16 mm gypsum board 19 mm sleepers 12 mm Duralux strips (rubber)	61	58
18	Carpet 6 mm Duralux 16 mm plywood 16 mm gypsum board 19 mm sleepers 12 mm Duralux strips (rubber)	77	80
19	Hardwood 16 mm plywood 16 mm gypsum board 19 mm sleepers 12 mm Duralux strips (rubber)	57	56
20	Carpet 12 mm Duralux	79	83

Project Manager: Jacques Rousseau

Research Report: *Optimization of Impact Sound Insulation in Steel-Frame Floors in Residential Building*

Research Consultant: Guy Carrier, Acoustec Inc.

A full report on this project is available from the Canadian Housing Information Centre at the address below.

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